AN INVESTIGATION OF THE INTERRELATIONSHIPS BETWEEN PRODUCTION MANAGEMENT AND PROJECT MANAGEMENT

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THESIS

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BETWEEN PRODUCTION MANAGEMENT
AND PROJECT MANAGEMENT

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ABSTRACT

An investigation is made into the interrelationships between the discipline of production management and the project management process. Two specific examples are presented which demonstrate the impact of production management in the system life cycle of an acquisition program. Information gathered by personal interviews, field trips, questionnaire analysis, and literature review is presented which portrays the significant value that a knowledge of various elements of production management can have for a project management team.

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I. INTRODUCTION

The project management[1] approach to the acquisition of major weapons systems has been the subject of many reports, studies, and directives in recent years. Although numerous aspects of this management tool have been explored in depth, the authors feel that the relationship between project management and industrial engineering and/or production management has not been given the attention and exposure that it warrants. It will be the objective of this thesis to demonstrate the importance of production management to the project management organization and to portray the significant role played by industrial engineering/production management in specific phases of the weapon systems acquisition process.

A three pronged approach was made toward gathering the information required for such an analysis. These were:

1. A comprehensive literature search of books, periodicals, theses, directives, reports, studies, and questionnaires developed for previous studies.

2. Interviews with civilian and military project managers, Naval Plant Representative Office (NAVPRO) personnel, in-plant

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[1]Within the Navy, the terms "project management" and "project manager" are considered to be synonymous with the phrases "program management" and program manager" as used in DOD directives and civilian industry. The word "project" will be used in lieu of "program" throughout this paper.

production personnel, and academic personnel familiar with both production and project management.

3. Field trips to the production facilities of civilian corporations and government-owned-contractor-operated (GOCO) plants.

This process enabled viewpoints to be obtained from many diverse interests and at the same time permitted the authors to obtain a good familiarity with the day-to-day working environment in production facilities which ranged from ultra-modern to near obsolete and which were operating from one-fourth to full capacity.

II. DEFINITION OF TERMS

Prior to embarking on a discussion tracing the subject interrelationships, it is necessary to define some terms so that a base for the ensuing discussion may be established.

A. PROJECT MANAGEMENT

The concept of program or project management has long been a management tool of civilian corporations which served to provide a focus of resources and direction on particular programs within the corporate structure. The foundation for utilizing this approach within the military for the acquisition of major weapons systems is found in Department of Defense Directive 5000.1 which calls for the management of the development and production of major defense systems by a single individual--the project manager. The scope of duties envisioned by this technique are summed up in the following quotation:

> The concept of program management is to provide centralized management authority over all of the technical and business aspects of a program. The program manager's role, then, is to tie together, to manage, to direct the development and production of a system meeting performance, schedule, and cost objectives which are defined by his Service and approved by the Secretary of Defense (SECDEF). The essence of the program manager's role is to be the agent of the Service in the management of the system acquisition process, to focus the authority and responsibility of the Service for tuning the program. He has the vantage of a large perspective of the program and the interrelationships among its elements. He must be the major motive force for propelling the system through its evolution. [LOGISTICS MANAGEMENT INSTITUTE, 1971]

While a major focus of this thesis will be on the project manager himself, the subject of project management will be addressed in much broader terms so as to uncover the contributions to the total program effort by the lower echelons of management in the area of production management/industrial engineering. For example, the duties of the staff of a Naval Plant Representative Office will be discussed.

B. SYSTEM LIFE CYCLE

The life cycle of a system refers to the futuristic philosophy that recognizes the events that will effect a system during the period of its existence--first as an idea and then as a piece of hardware. Although the phrases used to describe the various stages in the life of a system change over time, the concept remains the same. Figure 1, System Life Cycle, presents one graphical expression of this concept.[1] Our primary areas of concern will be those segments shown as the Planning and Acquisition Periods as these periods are normally administered through the project management technique.

C. PRODUCTION MANAGEMENT/INDUSTRIAL ENGINEERING

These two terms have had many meanings over the years but application of the scientific method to man's thinking on management and production principles and methods has resulted in the emergence of a scientific form of management which has

[1]The permission of Dr. Melvin B. Kline to reproduce this figure is gratefully acknowledged.

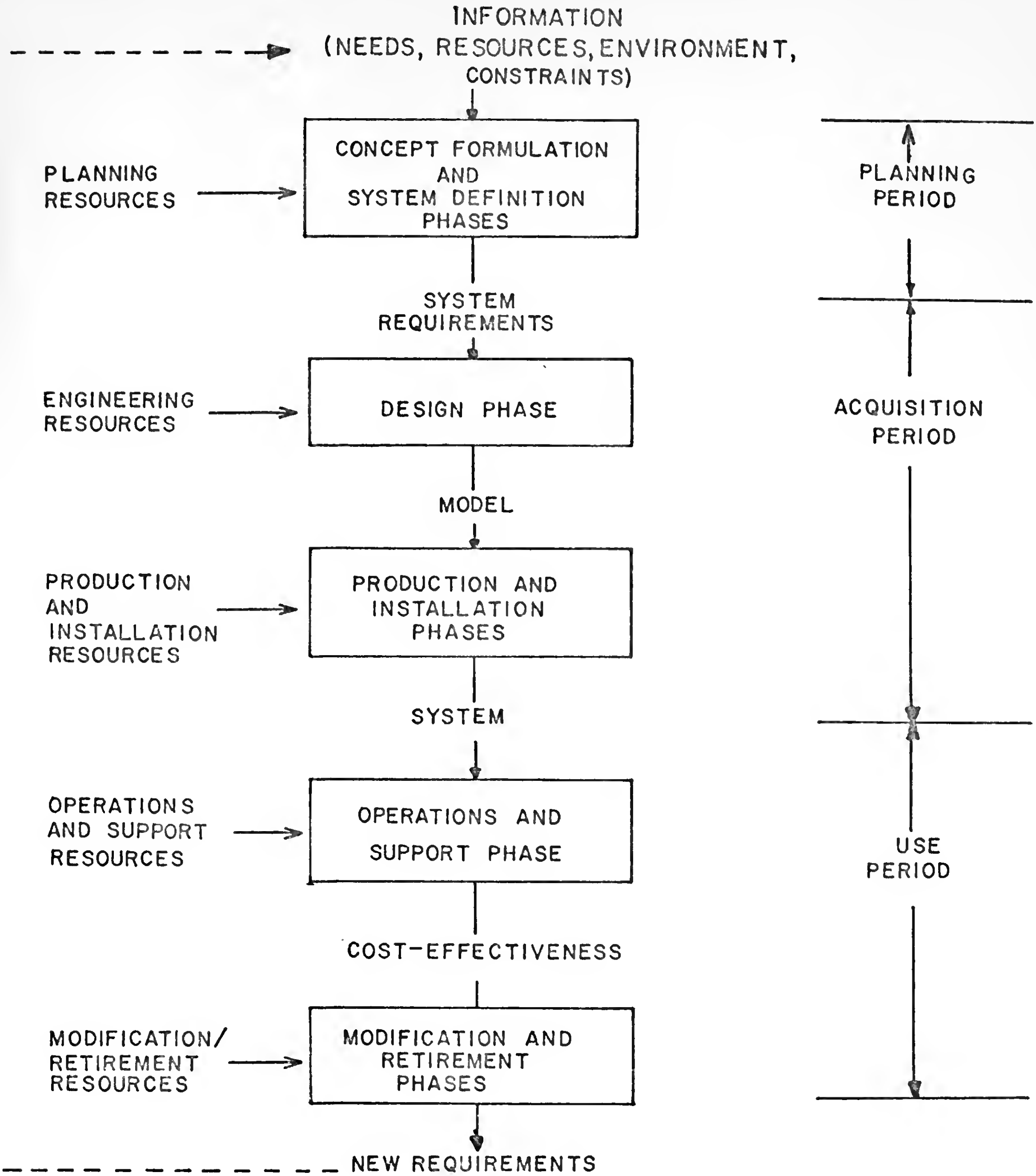

FIGURE 1 SYSTEM LIFE CYCLE

come to be known as production management. During this evolutionary process, these two terms have merged to the extent that they appear to be mutual subsets of each other in the current literature. Modern definitions of each will serve to support this contention.

> INDUSTRIAL ENGINEERING - is concerned with the design, improvement, and installation of integrated systems of men, materials, and equipment. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems. [MAYNARD, 1971]

> PRODUCTION MANAGEMENT - the art and science of properly and efficiently using men, money, and machines, materials and processes to economically generate goods and services. [AIR FORCE SYSTEMS COMMAND, 1971]

In view of these definitions, these terms will subsequently be considered synonymous in this paper. Further, since the term "production manager" is normally reserved for a specific top management position, those personnel who practice the art of production management will be referred to as industrial engineers.

Moving from generalities to specifics, modern production management is envisioned as consisting of the following disciplines and/or activities: [MAYNARD, 1971]

1. Selection of processes and assembling methods.
2. Selection and design of tools and equipment (tooling).
3. Design of facilities, including layout of buildings, machines and equipment; material handling equipment, raw materials and product storage facilities.
4. Design/improvement of planning and control systems for distribution of goods and services, production, inventory, quality, plant maintenance and engineering.

5. Development of cost control systems such as budgetary controls, cost analysis, and standard cost systems.

6. Product development.

7. Design and installation of value engineering and analysis systems.

8. Design and installation of management information systems.

9. Development and installation of wage incentive systems.

10. Development of performance measures and standards (including work measurement and evaluation systems).

11. Development and installation of job evaluation systems.

12. Evaluation of reliability and performance.

13. Operations Research, including such items as mathematical analyses, systems simulation, linear programming, and decision theory.

14. Design and installation of data processing systems.

15. Office systems, procedures and policies.

16. Organizational planning.

17. Plant location surveys which consider potential markets for the plant, raw material sources, labor supply, financing and taxes.

From this comprehensive listing, it should be apparent that production management has progressed a long way since its identification with solely Time and Motion Studies and Plant Layout. Further, documentation is available that indicates that a high degree of commonality exists in the subject matter content of production management as viewed by industry and the academic community [WILSON, 1953].

Perhaps the most comprehensive attempt to link production management to the project management process is the DOD Systems and Equipment Planning Guide [LOGISTICS MANAGEMENT

INSTITUTE, 1969]. Recognizing production management as an integrating function, given time and cost constraints, it is viewed as consisting of the following elements:

1. Producibility

2. Plans and controls for configuration, quality assurance, production requirements, cost, and schedule.

3. Manufacturing

4. Inspection and test

5. Equipment and tools

6. Facilities

7. Industrial support

8. Personnel and training

9. Funding

10. Control data

A similar Air Force publication [AIR FORCE SYSTEMS COMMAND, 1971] expands these elements further. Both documents focus on the attitude that management attention has been too long directed toward technical development problems at the expense of production efficiency. This group of ten elements is considered to be a more concise and manageable description of the scope of production management than the seventeen items previously listed. All subsequent discussion will assume production management to include these specific subject areas.

III. PRODUCTION MANAGEMENT AND WEAPONS SYSTEMS ACQUISITION

A. IMPACTS ON SYSTEM LIFE CYCLE

The objective of the Weapon System Acquisition process is to obtain a weapon system that meets its performance specifications, on schedule, and within cost. To achieve this objective production management must be a consideration long before the production phase of the system life cycle is entered. It must begin in the concept formulation stage and continue throughout the acquisition period if the large cost savings attainable in the production phase are to be realized. Figure 2, Impacts of Early Production Planning, and Figure 3, The Pattern of Deeper Involvement and Decreasing Options, rather vividly demonstrate the truth of the preceding statements. The cross-over point for both graphs occur near the end of the validation phase (which correlates to the system definition phase in Figure 1). Beyond these points commitment to decisions made in the conceptual and system definition phases of the life cycle is increased due to decision inflexibility caused in large part by the drastically increased unit cost of making changes.

Integrated planning for production throughout the planning and acquisition periods facilitates achievement of lower cost per unit throughout the life cycle of the weapons system. Each phase of the system life cycle requires further elaboration

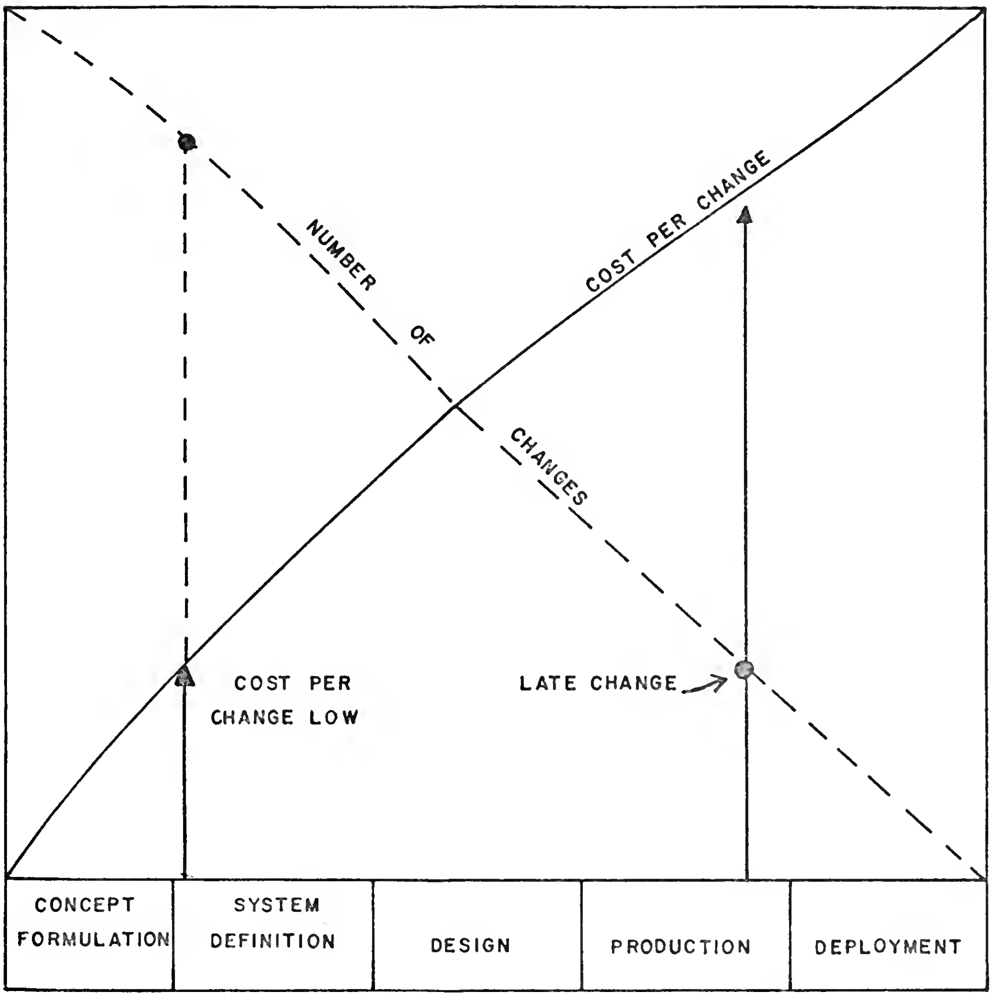

FIGURE — 2

IMPACT OF
EARLY PRODUCTION PLANNING

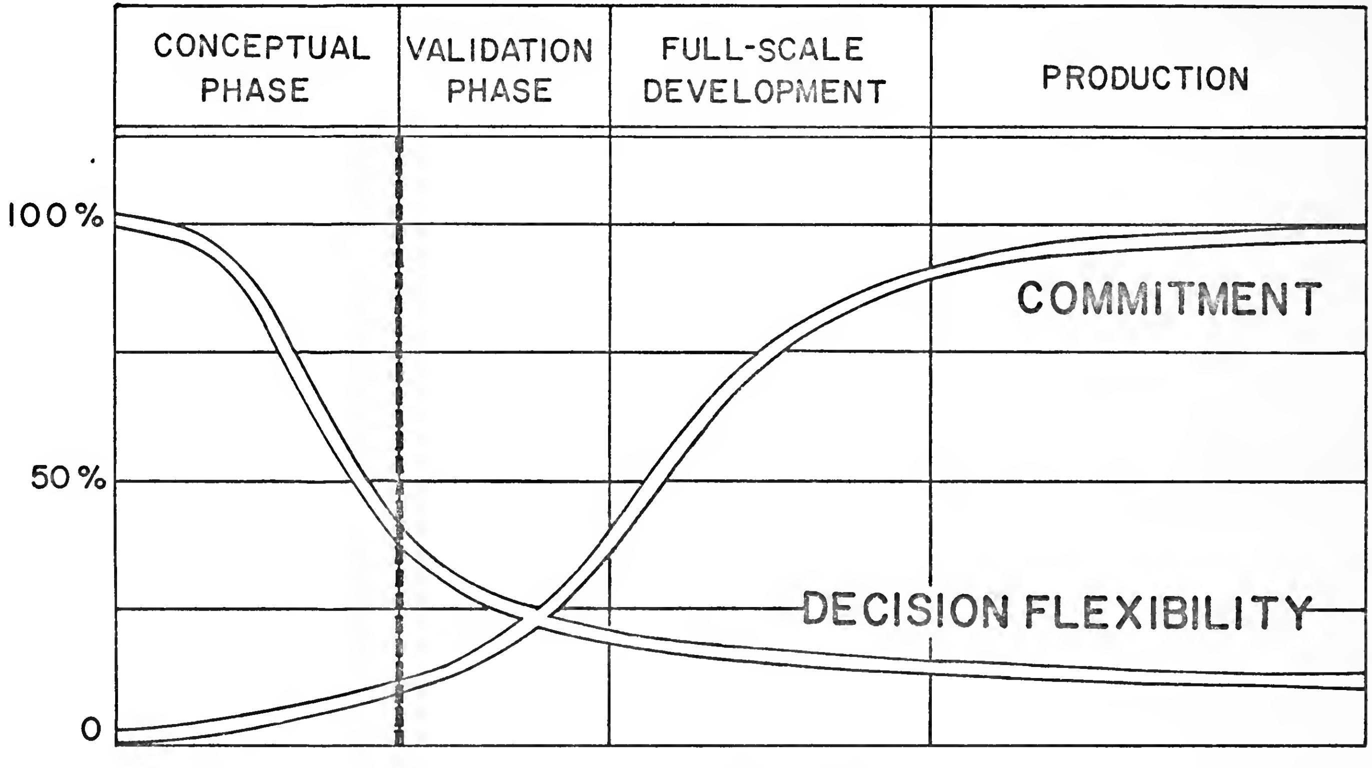

FIGURE - 3
THE PATTERN OF DEEPER INVOLVEMENT
AND DECREASING OPTIONS

to demonstrate the inter-relationships of production management to systems acquisition.

The primary source documents utilized in examining each of the following phases of the system life cycle were the Guide for Integration of Planning for Production, [DEPARTMENT OF DEFENSE, 1969] and DOD Systems and Equipment Production Planning Guide, [LOGISTICS MANAGEMENT INSTITUTE, 1969].

1. Concept Formulation

In this initial phase the need for new military capability is realized and a concept which will provide this capability is conceived. The process is iterative in nature and is supported by various experiments, tests and analyses. The result is a description of an operational capability and a weapons system to fulfill it. It is in this phase that the weapon systems requirements are identified through a program plan which broadly defines and quantifies the performance, cost, and schedule objectives. It is necessary in this phase to develop production feasibility estimates for each of the alternative weapons systems. Consideration must be given to the adequacy of present production techniques, requirements for interchangeability, availability of critical raw materials, and the necessity for long lead production capabilities. The results of these deliberations are collated into a production plan which includes not only the production elements cited earlier, but also production quantities, mobilization policy, automated programming for

o demonstrate the inter-relationships of production manage-

ent to systems acquisition.

tools and configuration management, quality, cost and schedule controls, and flexibility.

Although this phase of a system life cycle is generally characterized as being the least costly, that is probably true only in an accounting sense. If the cost incurred in other phases of the system life cycle due to inadequate planning in the concept formulation phase were to be applied to its accounting cost then the true cost of concept formulation might be realized.

2. <u>System Definition</u>

In the system definition phase preliminary designs and engineering for the weapon system are verified or accomplished, management plans are made, proposals for engineering development are solicited and evaluated, and the development contractor is selected. The objective is to verify the soundness of the early conception effort and to insure that the technical and economic bases for initiating full scale development of the weapon system are valid.

Contractor response to the Request For Proposal (RFP), offered during this phase, will be effected by the requirements laid down in the RFP. These requirements must be such as to permit evaluation of contractor proposals for 1) the degree to which they meet or exceed minimum requirements for production; 2) comparative credibility of their production cost estimates and impact on life cycle costs; 3) comparative producibility and risk of their manufacturing processes; 4) an effective plan for demonstrating the product against

production specifications and 5) the adequacy of their make/ buy relationships.

Again all the elements of production must be examined as to their criteria for planning, the proposals for their make-up, and final approval of their plans. Taken together, the individual element plans will constitute the production development plan.

3. Design

This phase begins a massive commitment of resources, for it is here that the total system, including all items necessary for support, is specified in detail, developed, fabricated in limited quantities, tested and evaluated. Most of the research and development monies allocated to the system are expended here.

The production of test units during this phase, in accordance with the production development plan, provides the opportunity to refine system design, resource allocations, and production processes. Generally it is the phase in which the "bugs" are ironed out, not only in the system test models but the production plan itself. Throughout this phase production management guidance for each of the production elements is required to assure that each of the element requirements are properly generated. interfaced and programmed into the production plan. It is here, concurrent with the production of test. units, that planning for the operational units must be done. The production plan must include the changes in design and support that become apparent from system and

subsystem testing. Any other changes should have been made early in this phase and in any event all changes must be monitored for their impacts upon production and material requirements.

The outputs from this phase are a complete and detailed system definition, test and evaluation results, a firm production plan, and cost targets for hardware and supporting items.

4. Production

This phase begins when the production contract is negotiated and awarded. It is in production where the greatest commitment is made with respect to total resources. Public announcement of the contract, the extensive time and monies committed, and the needs of the operating forces preclude turning back.

The production plan is implemented and production thresholds are monitored. Production extends somewhat into the deployment phase which may result in subsequent modifications of the original system. In any event, modification may result either from system deficiencies showing up in use or for modernization purposes. Thus the use of the production base line plan may extend far beyond the production phase itself though the plan will no doubt be modified considerably.

The preceding discussion was not intended to be comprehensive by any means. The sole purpose was to demonstrate that production is a factor for consideration in every phase of the weapons system acquisition cycle. Further amplification of this point is provided by Figure 4, Production Cycle,

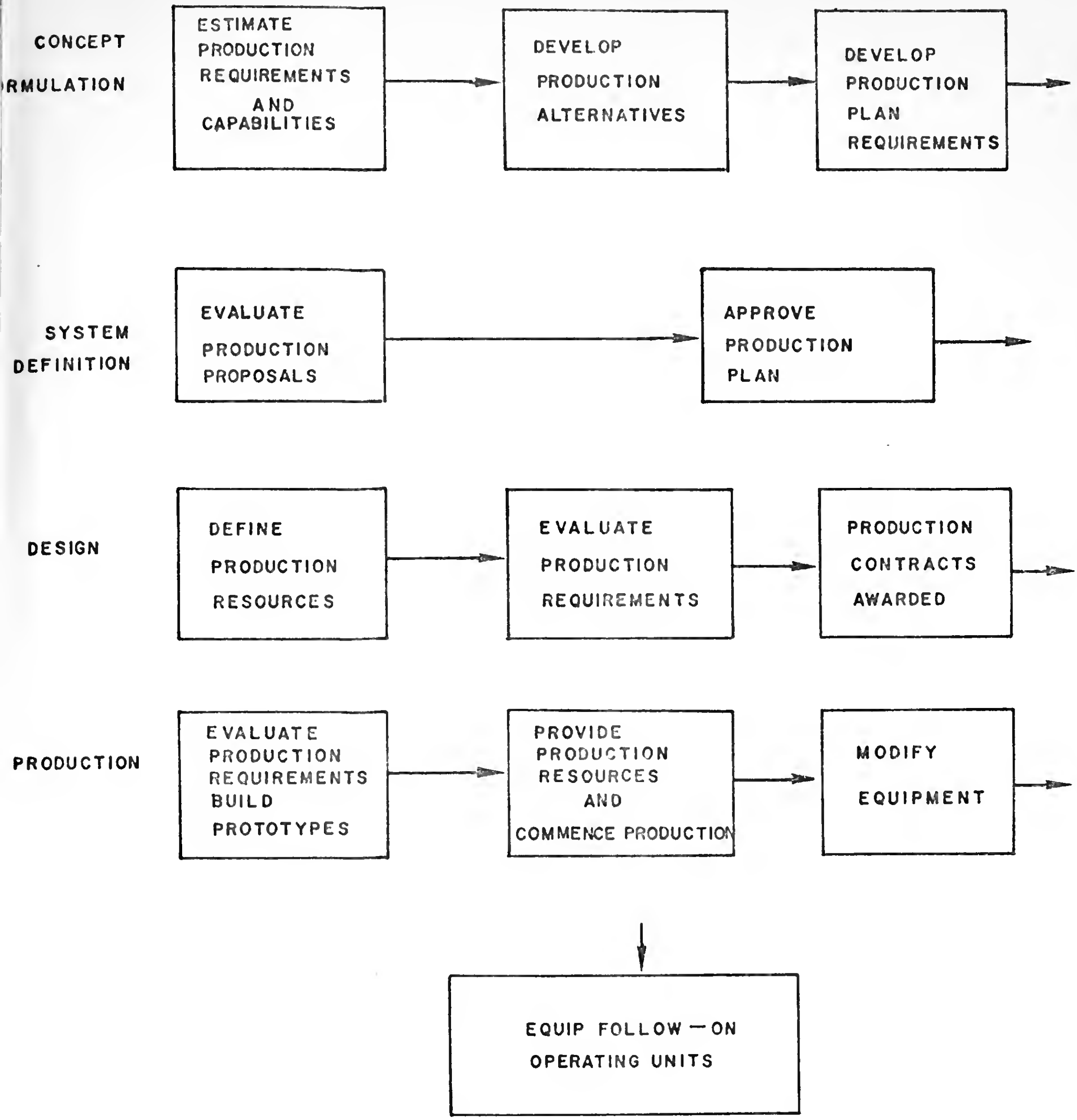

FIGURE 4

PRODUCTION CYCLE

which illustrates the production cycle contained within the system acquisition cycle.

B. PRODUCIBILITY/CHANGE CONTROL

The pervasiveness of production management throughout the system life cycle might be considered sufficient evidence that more than a cursory knowledge of production management would be of benefit to the project manager. However, further support for this contention will be gained through the examination of two subsets of production management: producibility and change control. It would be presumptuous to say that these two areas are more important than the other elements of production management, but they arose as separate topics for discussion in almost all of the interviews the authors conducted. Additionally, each of these areas has received increased emphasis of late and are likely to be topics for discussion for some time in the future.

1. Producibility

The term"producibility" has been used for a few years, but often with varied meanings and in different contexts. Often it is confused with the terms production capability or production feasibility which both refer to a determination that the system can be fabricated.

Producibility is an element of production management planning. It is defined by those characteristics that lead to the most effective and economic means of fabrication, assembly, inspection, test, installation, checkout, and

acceptance of systems or equipment through the production planning and equipment design processes. These considerations include materials, tooling, test equipment, facilities, people, and procedures; all of which support the production cycle. Since it is an element of production planning, producibility must also be a consideration through the system life cycle. The earlier producibility is a consideration the more likely operational and economical trade-offs of the equipment design, support, and production requirements will take place. The end result of this action would be increased production effectiveness at lower total cost. Thus producibility has to be a consideration in the concept formulation phase and a producibility plan must be devised enumerating producibility goals for design definition, production specifications, and actual measurement of producibility itself. This plan in turn would become part of the overall production plan. Additionally, to facilitate dealing with the contractor some criteria must be established to evaluate the contractor's ability to develop a producible system design. If he is working up the preliminary design he should be contracturally obligated to develop producibility characteristics and goals to be used in his design and production planning requirements. Such design guidelines might be:

1. Constraints on critical types, quantities, and application of materials.

2. Constraints on the application of processes, such as forming, bending, machining, etc.

3. Requirements for selection of design alternatives permitting achievement of designated production line capabilities.

4. Constraints on employment of high risk vs. proven methods and processes.

5. Constraints on tooling development vs. utilization of available equipment.

In fulfilling the preceding with respect to the contractor it would be reasonable to expect a disagreement(s) to arise with the government over the criteria established for producibility or over the actual determination of what constitutes an effective producibility analysis. In such event the Air Force Systems Command Manual on Production Management provides excellent guidance:

> In this area the interests of the government and the contractor may conflict, with the latter's analysis of producibility and recommended approaches to quantity production unduly influenced by the desire to employ his peculiar capabilities, proprietary processes, and maintain his working force. The contract administration services production personnel should effect involvement with contractor design engineering in sufficient depth to avoid such subjectivity and provide program management with an appreciation where design proposals, configuration management documentation (for example: specifications, trade-off studies, and producibility analysis), and production plans reflect approaches which require the program to underwrite extra expenses through resort to unnecessarily costly or comparatively inefficient quantity production practices.

Within the last few years the idea of producibility has become increasingly important. It is viewed as a means

to combat the ever increasing cost of acquiring new weapons systems. Producibility departments are being set up within organizations to insure its benefits are extracted. Another factor promoting producibility is the advent of the "Design to Cost" concept within DOD. This will place added emphasis on producibility for some time in the future.

"Design to Cost" is a phrase used in DOD since 1969. No standard, or rather official, definition of this term has been promulgated to date. The generally accepted interpretation is as follows:

> Cost parameters shall be established which consider the cost of acquisition and ownership; discrete cost elements (e.g., unit production cost, operating and support cost) shall be translated into "design to" requirements. System development shall be continuously evaluated against these requirements with the same rigor as that applied to technical requirements. Practical tradeoffs shall be made between system capability, cost and schedule. [DEPARTMENT OF DEFENSE DIRECTIVE 5000.1, 1971]

Close examination of the quotation reveals a remarkable similarity to the concept of producibility. The difference lies in the emphasis on cost. The authors submit that if an item or component is evaluated as to its capability of being produced and its optimization of material applications, manufacturing methods, fabrication processes, production schedules, personnel training requirements, and costs then not only are the objectives of producibility fulfilled, but also those of "design to cost." "Design to Cost" is in essence producibility with a cost bias. For this reason producibility, as an element of production management, will be a prime consideration of project managers for some time to come.

combat the ever increasing cost of acqu[illegible]

stems. [illegible]

2. <u>Change Control</u>

A quotation from a recent General Accounting Office report demonstrating the magnitudes of the cost growth problem serves as an excellent introduction to the topic of change control.

> Cost histories of 45 systems under development on June 30, 1972, show that current estimates of cost to acquire the systems increased by some 31.5 billion dollars--39 per cent over the planning estimates and 19.1 Billion dollars--20 per cent over the development estimates. It is these widely publicized overruns that have shaken public confidence in the ability and credibility of both government and industry managements. [GENERAL ACCOUNTING OFFICE, 1973]

The cost growth figures cited are based on unit costs of the system. Causes for these cost changes are attributed to:

1. inaccuracy of original estimates

2. inflation

3. revisions to the specifications--time schedules, quantities, or engineering changes

The relative condition of each of these causes to total cost growth is depicted in Figure 5, What Causes Overruns?.

The largest contributor to cost growth is changes in the requirements. Engineering changes (synonymous with design changes), in particular, have the capability of not only revising specifications but impacting on schedule. If the cost of making these changes is great enough it may even force a reduction of quantities ordered, in turn driving up costs.

The reason for engineering changes range from new mission requirements established by DOD, to faulty performance specifications, to misunderstanding of contract terms. For many of the 45 systems specified, engineering changes

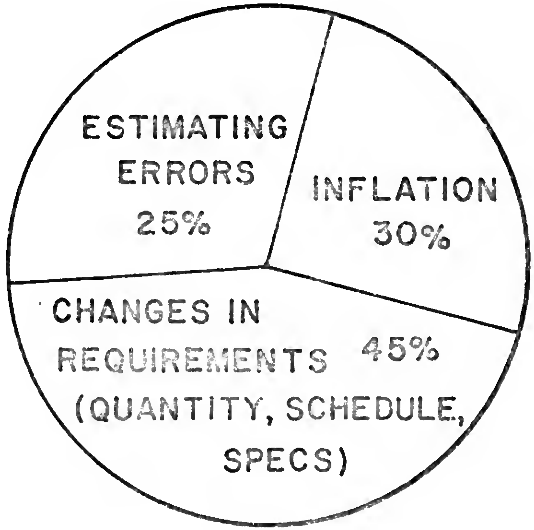

FIGURE - 5

WHAT CAUSES OVERRUNS ?

were brought about by the adoption of concurrency, (i.e., production was started before development was complete). As a result many problems dealing with the design of the system did not surface until after other units were proceeding through production. Concurrency, though warranted in special circumstances is discouraged in the large complex weapon system acquisitions as official policy.

Another reason promoting engineering changes is that the contractor line production organization that ends up with the production task frequently has had little direct influence on the original production decision. This means that anticipated costs, methods, and tooling have been established by personnel or organizations remote from the parts making responsibility. Problems in establishing efficient production procedures are then reflected in costs. Development oriented personnel, both DOD and contractor, who may have been the driving force in the generation of new methods or products frequently have a very shallow knowledge of the degree of in-process product and process definitions required to guarantee trouble free production. The end result is either an inefficient production process or engineering changes, or both.

Knowing why engineering changes occur is important, but understanding why they contribute so much to cost produces a valuable insight to the problem. It is with this in mind that the following discussion is directed. Figure 6, Production Program, illustrates a production program which

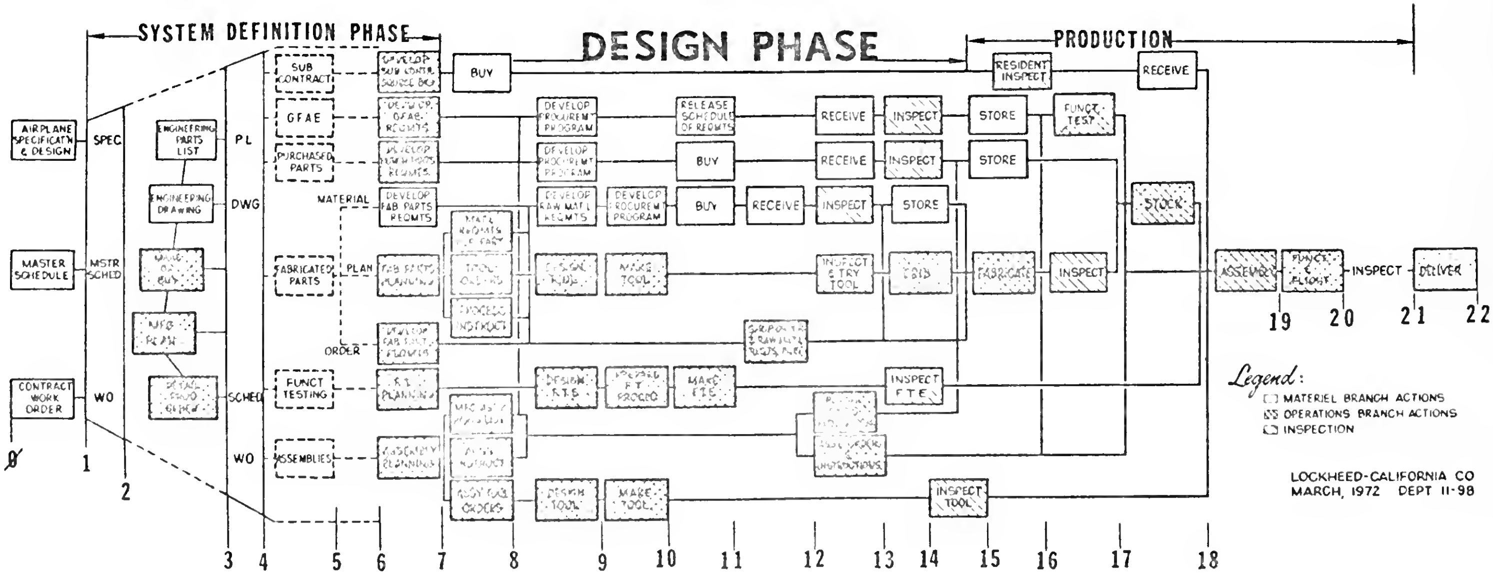

FIGURE 6

PRODUCTION PROGRAM

(Courtesy of
Mr. E. F. Davis;
Industrial Engineering Manager.)

the Industrial Engineering Manager of an aerospace firm indicated was fairly typical of at least the aerospace industry with perhaps broader application to other industries. Referring to this figure, the numbers 0 through 22 do not indicate successive steps but are used simply as a reference aid for ease of discussion. Initially the functions 0 through 7 would be encompassed in the system definition phase of the life cycle and functions 7 through 14 the design phase. Once production prototypes had completed testing then the production in quantity would commence at number 14 and work through to number 21. The interesting aspect of Figure 6 is that any engineering changes must begin at number 0 regardless of how far along the system might be in the production program. Figure 7, General Operating System, more clearly illustrates the steps required to process an engineering change. It then becomes evident the personnel performing the functions from 0 to 14, or those cited in Figure 7, must be maintained in many cases simply to process the engineering changes which historically always occur. This being true, it is easy to see why it becomes so difficult and expensive to implement changes when the system goes beyond the system definition phase. More succinctly:

> The burden of maintaing a smooth, uniform flow of trouble-free production under effective cost control is not compatible with new ideas. [WEISMANTELE, 1969]

The above quotation points to the need for change controls. Such controls are often established vis-á-vis the configuration control or standardization boards. Occasionally

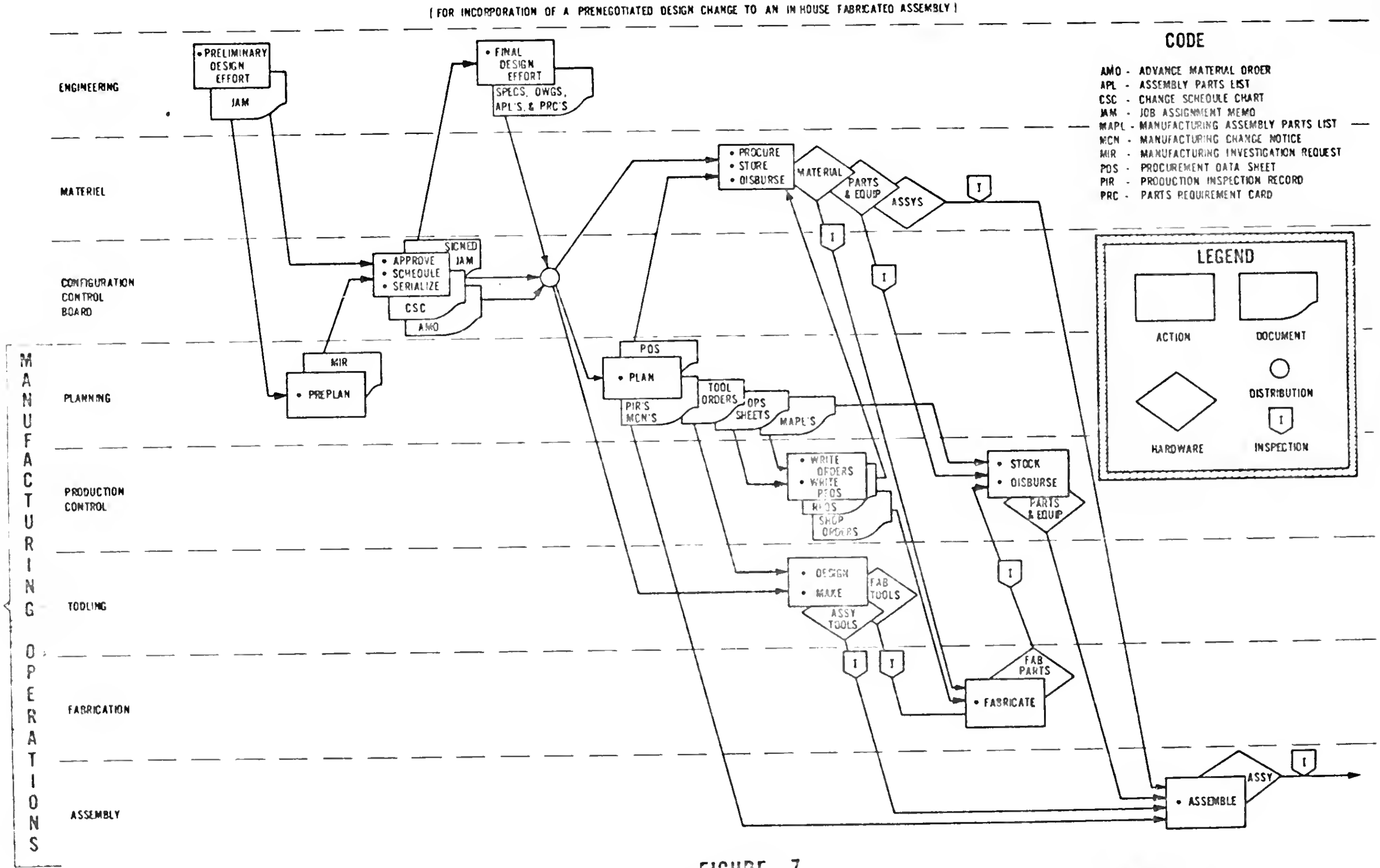

FIGURE 7

GENERAL OPERATING SYSTEM

(Courtesy of
Mr. E. F. Davis;
Industrial Engineering Manager.
Lockheed Cal, Co.)

these procedures are looked upon as administrative in nature when in fact they have a very definite impact on the production process.

It is vital that the project manager and his staff recognize the need for controlling engineering changes, not just from the dollar standpoint, but from a production standpoint. Viewing the impact from a production standpoint will easily translate into dollar impact, but has the additional advantage of promoting insight into the real problem...that problem being, of course, to keep a focus on schedule and performance as well as cost, and to maintain an acceptable balance between them.

ence procedures are looked upon as [illegible] in nature

IV. RESEARCH FINDINGS

Three principle sources were used in attempting to validate the conclusions of the previous section regarding the impact of production management on the project management process. These were questionnaire analysis, personal interview and observation, and literature review. Because of the range and depth of the material uncovered, each area merits individual discussion.

A. QUESTIONNAIRE ANALYSIS

The questionnaire referred to is one that was developed by a faculty/student committee at the Naval Postgraduate School in April 1971 [ERICKSON, et al, 1972]. Its purpose was to provide an input from personnel with significant experience in the area of project management to assist the committee in its task of formulating a graduate curriculum in Weapons System Acquisition Management (WSAM). The majority of recipients of the questionnaire were present or previous Navy Project Managers; however, some questionnaires were distributed to other senior military officers and civilians associated with the acquisition of major weapons systems in the Department of Defense.

The questionnaire was particularly valuable to our research effort because of its recent dating and because it elicited from many major participants in the project management process their views on many aspects of this process,

particularly production management and the project manager. Additionally, the original questionnaires as returned by the recipients, were available. This reservoir of information allowed the authors to forego the time consuming and expensive process of contacting a large sampling of project management personnel which would have been an otherwise necessary part of our research effort.

The respondents were first asked to rank fourteen subject areas, one of them being production management, on a scale from zero to ten (zero = low importance; ten = high importance) with regard to their importance to a project manager. The fourteen subject areas were:

1. General Management
2. Financial Management
3. Procurements and Contract Administration
4. Acquisition (Project) Management
5. Personnel Management
6. Resource Management
7. Technical Management
8. Data Management
9. Production Management
10. Operations Analysis
11. Behavioral Sciences
12. Economics
13. Political Science
14. Marketing

Tabulation of the questionnaire results indicated that Production Management was ranked seventh in importance by the respondents. Further analysis of the results revealed that of one hundred and seven (107) questionnaires available for inspection, 67 or 62.6% scored Production Management between seven and ten. This would indicate more than a cursory interest in this area by project management personnel.

Production Management as defined in the questionnaire included the following subject material, ordered with decreasing importance as determined by the results of a ranking procedure similar to that described above:

1. Configuration control
2. Changes
3. Quality assurance
4. Customer/contractor relationships
5. Scheduling techniques
6. Reporting
7. Inspection and acceptance
8. DCAS (Defense Contract Administration Services)
9. Value engineering
10. Industrial engineering
11. Industrial labor problems

Reference to our adopted definition of production management will reveal that each of the topics addressed in the above listing fall within its scope. Of even more significance, however, were a number of specific comments provided by the

respondents regarding Production Management and its various subject areas as defined by the questionnaire. It is informative to list a few of them:

> Since Project Manager training will be useful for NAVPRO and DCAS duty, this is a desirable area.

> Knowledge in these areas will certainly provide a good background for the day-to-day contact with the contractor. Consider this a highly essential area.

> A significant omission is that of planning and control which I would rate 10 vis-á-vis the other items.

> Summary treatment of this element will equip the Project Manager to understand the importance of these topics when he deals with production oriented personnel.

> Most project officer personnel are short on the art of system design with a view towards manufacturing producibility and ship installation.

> I doubt that this stuff can be taught effectively in a cram course--again, the proper project manager selectee has become exposed through "on the job training" and this would be a useful refresher. His production staff on the other hand should be deeply involved all the time and his job is to see that they are on top of their problems.

> Production is not done by the acquisition manager, but he must have thorough understanding of production methods and problems.

> Important to have skills to personally monitor and evaluate contractor's performance.

> The objective of the weapon system acquisition process is to produce hardware for the operating forces of the Navy and Marine Corps. Therefore, production must be successfully managed regardless of other program successes.

> NAVAIR has a strong production group and in the project office is represented by an assistant project manager experienced in these elements.

> The project manager should have a good general feel for what is happening to his end item during the production cycle but need not have a great deal of expertise since he will always be able to get help from those who are production specialists, i.e., plant rep offices or command production specialists.

A good production manager is a must on the WSA Manager's team. Tell him what you want accomplished--not how to do it!

I consider a contractor, part and parcel, a large part of the ACQUISITION TEAM. Hands off policy is killing the government, and we must recognize the MILITARY/INDUSTRIAL Team as the Acquisition Team. Let the contract officer/ negotiator do their job in support of the Acquisition Manager, not in spite of nor in a void.

DCAS organization needs to be utilized more heavily. Engineering capability of DCAS is not widely enough known and possibly their depth is insufficient to establish a reputation.

He should know a lot about acceptance criteria, quality control, configuration control. He must be knowledgeable about Engineering changes and understanding of contractor problems. In general, I don't think he gets involved in details of production management and only those aspects wherein an understanding may help explain delays or quality need be addressed. He needs to know about the DCAS and PLANTREPO functions because he will be dealing with these organizations.

These should all be taught within the framework of DCAS and its responsibility in these areas, with emphasis on how to use and influence the DCAS organization.

It is apparent from these quotations, there is a wide diversity of opinion on the depth of involvement of the project manager himself in the production process. Noteworthy, however, is the emphasis on the proper utilization by the project manager of other members of the project management team in this area. To do this it would seem desirable that the project manager have more than a cursory familiarity with the elements of production management. Further, since the above comments tend to spotlight efficient and full utilization of the NAVPRO and DCAS organizations, it is only reasonable to assume that the personnel staffing these groups

should also be possessed of more than superficial knowledge in this discipline.[1]

B. PERSONAL INTERVIEWS AND OBSERVATIONS

1. Interviews

a. Academia Representatives

Contacts with this group were rather limited principally due to the fact that there are few members of the academic community that are reasonably familiar with both production management and the project management concept. However, two ideas regarding the role of production management in the project management process did surface.

The first concept involved the interfacing process joining the design engineer and the production process. Figure 8, The Role of Producibility, depicts this relationship and serves to expand the term Producibility, which was previously discussed. For the present, suffice it to say that the academic community envisioned producibility as the main production management concern of the project manager in the design phase of the system life cycle while the preponderance of production management expertise would be utilized in the production phase of the life cycle.

The second contribution of the academic community to the research effort concerned the stimulation of the

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[1]This remark could equally be applied to personnel of the supervisor of Shipbuilding (SUPSHIP) organization, the shipbuilding counterpart of the NAVPRO group in aircraft and ordnance production.

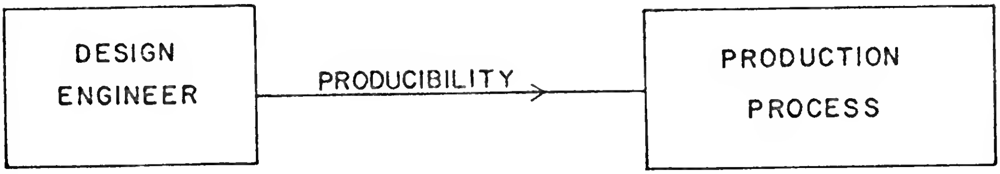

FIGURE 8
THE ROLE OF PRODUCIBILITY

awareness that an intuitive "feel" for "what it takes to make things" was an essential ingredient for a successful project management staff. It was noted that this intangible perception ability often eluded many individuals and greatly impaired their ability to function in an industrial environment. This "feel" became a goal of our research effort through the mechanism of field trips to industrial facilities.

b. Civilian Project (Program) Managers

The personnel interviewed in this phase of our research had all functioned as the civilian counterpart of a military project manager in at least one Department of Defense sponsored system acquisition process. Consequently, they were eminently qualified to comment on the production management involvement of military project management personnel.

As was the case with the questionnaire respondents, a large diversity of opinion was evident with regard to the importance of production management to the project manager. Interestingly enough, the attitude seemed to vary with the academic background and experience of the interviewee. Those with production management in their background (either academic or on-the-job experience) considered it to be an essential knowledge requirement of any project manager. On the other hand, those interviewees lacking in a production management background felt that military project management personnel needed only an understanding of the terminology of production so, as they stated, "I won't have to educate them."

Significant deviations from the above pattern were also noted, however. In one particular case, a project manager who subscribed to the "terminology only" philosophy physically moved his entire project staff into the production plant to constantly monitor the production process because "it was necessary to get the job done"--an overriding consideration of all the project managers interviewed.

One project manager provided us with a list of items concerning his relationship with the government which tended to impede his efforts toward a successful completion of the program. Although all these complaints do not address the topic at hand, some do. It is instructive to examine the entire listing to obtain a feel for the relative breadth and depth of concern regarding those items relating to production management--those marked with an asterisk.

As was the case with the

1. The "adversary system" that seems to develop naturally on FFP and FPI type contracts.

2. Communication with the program office (PO) is in reality communication with four separate entities:

   a. program director and staff
   b. the technical community
   c. the logistic support community
   d. the procurement community

3. Internal communications within the PO.

4. Procurement is not under the control of the program director.

5. Differences of opinion and attitudes between the program director/technical community and the procurement community.

*6. The attitude that "all contractors are out to cheat the government."

7. PO often not open in their communications with the contractor.

8. Changes of program office personnel in the government.

9. The numbers of different personnel/organizations the contractor is required to interface with in the government on a specific program.

*10. Delayed decisions on the part of the government.

11. Interpretations of DOD/service rules and regulation by the program offices.

12. Contractor is often placed in the middle between the PO and the user.

13. Misunderstandings between the PO and the user.

*14. Coordination of changes with the government.

*15. Unrealistic specifications/requirements and resulting unrealistic test requirements.

*16. GFE engineering data and hardware deliveries.

17. Late involvement of logistic commands in program and subsequent delays in spares provisioning activities.

18. Late commitment to a logistic support concept and maintenance philosophy.

19. Spares procurement not in consonance with maintenance philosophy.

*20. Trying to keep a major production program rolling and still play by all the rules.

*21. Answer shopping.

22. Bypassing the chain of command in communication with the contractor.

*23. The attitude that the paper is more important than the equipment--imbalance problem.

24. Certain elements of a program always take a back seat--like training, training equipment, and simulation equipment.

In contrast to the academic community, no mention of producibility was made by this group. This seemed particularly strange in that one project manager had previously made his mark in the company as a design engineer.

Interestingly enough, the one common thread that ran through all conversations with the civilian project managers was their belief in being on the production scene and "getting down with the people." It would appear that this attitude is inconsistent with the preceding discussion, for to effectively mingle with the people involved in the production process, one would have to be possessed of more than a superficial knowledge of their methods and procedures. Their emphasis on this philosophy provided a testimony to the importance of production management that far outweighed the negative aspects of many of their previous statements. In short, when viewed in a "big picture" perspective, the value of a solid familiarity with the tools of production management became clearly evident.

c. Contractor Production Personnel

The recurrent theme in every conversation with these people was that the military project management personnel (including DCAS, NAVPRO) with which they interfaced were severely deficient in their knowledge of production management matters. Tempering their comments to allow for parochial interests still did not serve to eliminate this shortcoming as a valid complaint. The resultant on-scene education of these project management personnel was considered to be time consuming, costly and avoidable. The common desire was the wish that these people could be temporarily assigned to the plant in question for a short period to upgrade their industrial engineering skills.

d. NAVPRO Staff Personnel

Figure 9, A Typical NAVPRO Organization, depicts a typical NAVPRO staff structure. Not uncommonly, all positions except the Administration Director and Contracts Director are Naval Officers. Recent Navy policy has emphasized the role that the NAVPRO organization is to play:

> Field personnel must have sufficient awareness and understanding of a contractor's management philosophy, policy, problems and internal operations to assure that singular decisions and questions are considered on the basis of their effect on significant overall performances. [CNM, 1971]

Given this direction, it was surprising to find that not only was the feeling strong that the project manager needed a "terminology only" knowledge of production management but lower echelons in the NAVPRO structure--department level--

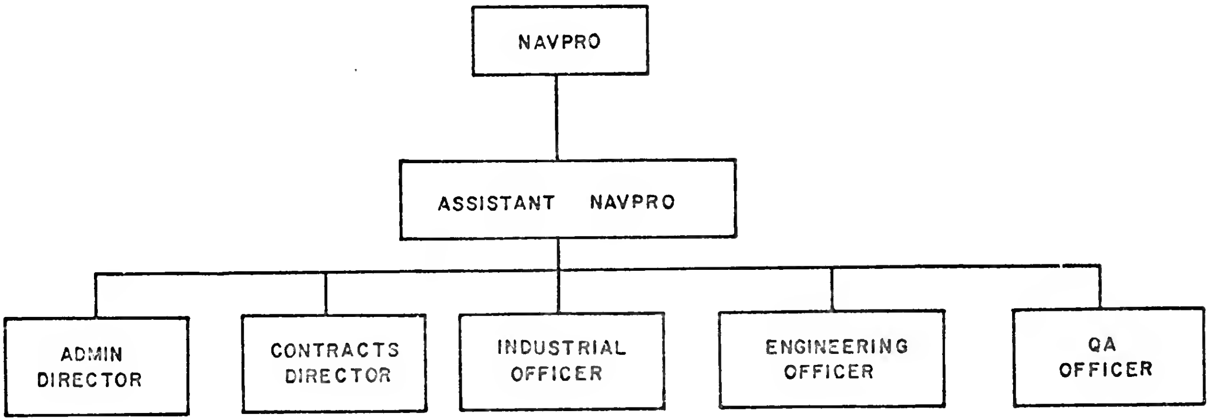

FIGURE 9 TYPICAL NAVPRO ORGANIZATION

viewed their billets as being of a general management nature and not requiring any technical or industrial engineering training. Although the former attitude can be explained by the desire of the NAVPRO to be allowed to accomplish the given task without the interference of the project manager, the latter is difficult to comprehend. It would seem that the guidance provided by the above quotation would be, at best, difficult to implement. Possibly this is a defensive reaction resulting from a lack of adequate training in the production management area. The comments of contractor personnel working in the plants over which the NAVPRO had cognizance certainly support this explanation.

e. Field Trip Observations

Preliminary to the field trips, it was felt that some knowledge concerning "what to look for" in industrial facilities was necessary. A typical article on this topic stresses getting out of the executive offices and into the plant where a good procedure is to trace the production of the end item backwards all the while taking note of such items as personnel attitudes, cleanliness, inspection procedures, and the flow of work in progress [WILSON, 1971]. This proved to be an excellent technique for developing a good "feel" for the operations of a plant.

As was alluded to earlier, a goal of these field trips was to attempt to obtain a good grasp of the principles of "making things." Through an appropriate selection of the industries and plants to be visited, this goal was achieved.

The key element in achieving this level of knowledge was the recognition that the procedures utilized in producing the end product vary drastically with two items in particular--plant capacity and age of production machinery and techniques. Thus, the production techniques viewed ranged from ultra-modern, numerically controlled, multi-process machinery to hand construction and plants operating from 25% to 125% of full capacity were visited.

The end result of these efforts was a reinforcement of the authors' contention that a project manager needs a solid foundation in production management if he is to intelligently administer his project staff toward successful production of his program's end item.

C. LITERATURE REVIEW

The overwhelming impression to be gained by a review of the literature of production management is that, historically, the industrial engineer has had and continues to have an identity crisis. A 1968 study, lamenting the plight of the practicing industrial engineer, noted that management was not only guilty of perpetrating this attitude, but was even reluctant to admit that he served a useful function. Further, the industrial engineer was not uncommonly referred to as an "efficiency expert" or a "necessary evil" [IRON AGE, 1968].

Indications that this attitude has also been present in the military systems acquisition process can be found in a recent book, The High Priests of Waste, by A. E. Fitzgerald. Fitzgerald portrays the Systems Analysis groups within the DOD

as discounting the value of industrial engineering techniques and measurements much to the detriment of the programs concerned. Further, he found that:

> Production control techniques which had been carefully evolved and refined over a period of sixty to seventy years were effectively abandoned. Orders for parts to be made in the factories would be released and immediately lost. Hordes of 'expediters' or 'part chasers' would then be unleashed to find the orders and shepherd the parts through the manufacturing process. By dint of much scurrying about, the parts chasers would round up enough parts to assemble a missile from time to time. [FITZGERALD, 1972]

Evidence that this grappling for an identity for the discipline of production management is also prevalent in the academic community can also be found. While stating that top policy managers must have a substantive knowledge of this field and be capable of intelligent conversation with the designers, planners, and implementers of production systems, one source allowed as how:

> Production management, in some form, is a logical constituent of most engineering curricula. The question therefore arises whether this topic rightfully belongs within less technical, business school curriculum. Although production has the connotation of being strictly an engineering function, managers make decisions about production matters using economic or even political criteria that are superimposed on the engineer's technological alternatives. There is a <u>technical</u> content to the managerial aspects of production management and decision making that is different from the technology of processing materials or providing services. It is this technical content that comprises the substance of business programs in general and production management in particular. [GAVETT, 1968]

Given this ambivalent attitude toward the industrial engineer, an examination of his parent discipline and the project management process is suggested. Without much risk of being controversial, it is safe to say that a major goal

of production management is economical production. Three fundamental criteria can be recognized to support this goal: [ARMSTEAD, 1969]

1. a simple design that fulfills the minimum specifications.

2. material selection process that considers workability/ machinability along with cost and specifications.

3. manufacturing process selection that emphasizes meeting specifications at minimum unit costs.

Any serious student of the project management process as applied to military systems acquisition policy will recognize this philosophy as part and parcel of the guidance given to project managers. So, it would seem, the goals of the project manager and production manager are not only compatible, but convergent.

While the charter of the project management concept in the military, DOD Directive 5000.1, is a very general document, there is much documentation within the individual services that allude to the interplay of production management and the project management process. For example, within the Navy, a specific level of project management relevant to Weapons Systems Acquisition is identified as Industrial Management [HALLADAY, 1970]. Further, the publication, Introduction to Military Program Management, authored by the Logistics Management Institute, provides the sound advice of one project manager:

> You are deep in contractor problems from the beginning. If you are going to do your job right, you have to know your major contractors--their history, organization, people, and the way they do business. To understand a contractor, you have to know something about what

> motivates business in general. Industry goes to great lengths to learn everything it can about its customer--the government. A program manager should do no less in learning about his major suppliers. [LOGISTICS MANAGEMENT INSTITUTE, 1971]

The publication goes on to point out that their appraisal of the situation perceives that contractors are more apt to respond to the candid appraisals of the project manager gained through personal involvement with the company's management team and effort.

As proof that production management is also considered a desirable item in the project management concept as practiced in the civilian community, consider the following quotation:

> The problems faced by a Project Manager with a lack of technical expertise are that he may lose technical control of a project and cause resentment on the part of participants who feel that he does not understand their position. A lack of technical expertise may also adversely affect the decision-making process. The project manager must either rely on team members for technical decisions or delay the decision until he can consult a third party. Participants may interpret this latter action as a lack of trust and respect for their professional competence. [GEMMILL et al, 1970]

Recently increased emphasis has been placed on production management disciplines with the advent of the SHOULD COST concept. This technique has as its goal the detailed evaluation of a contractor's cost and performance data in order to determine a government position as to what the production of a particular item should cost [BUREAU OF NATIONAL AFFAIRS, 1973].

V. CONCLUSIONS

Three significant facts can be deduced if the findings of the separate research area of Section IV are compared to each other and the production management-project management environment depicted in Section III. They are:

1. The occupants of project manager positions or their equivalent generally feel that a cursory knowledge of production management is sufficient to accomplish their objectives. This self-perception is to be contrasted with the feeling of lower echelon members of the project management team who feel that a solid foundation in this area is highly desirable.

2. The "terminology only" philosophy manifested by many project managers is in conflict with the explicit attention to production management considerations made necessary by the depth with which production management is shown to permeate the system life cycle.

3. In many instances, the denial by project managers of the necessity for a solid foundation in production management was contradicted by their personal behavior in meeting the requirements of their programs. Specifically, a "crash course" in production management was instituted in one case simply to overcome or avoid a problem relating to production.

Given these attitudes by personnel in high levels of management it is no wonder that production management has

taken a back seat to more academic oriented disciplines which can be mastered in the confines of the executive offices. Given the track record to date on many major acquisition programs, both civilian and military, one might conclude that the development of a more solid foundation in production management for project management personnel would be worthy of consideration. At a minimum, it is important to ensure that if the project manager himself does not have experience in production management, then an individual possessing this experience should be assigned to his staff.

The personal experiences of the authors in conducting this study indicate that a grasp of production management is best attained in the industrial environment itself where daily exposure to "how things are made" and the observation of the producers in action strip away the sterile entrapments of academia. One solution then might be to ensure that project management personnel receive some exposure to industrial facilities prior to assuming their assigned duties. To quote one civilian program manager when presented with this proposition: "Who knows, it might do us both some good!!"

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An investigation is made into the interrelationships between the discipline of production management and the project management process. Two specific examples are presented which demonstrate the impact of production management in the system life cycle of an acquisition program. Information gathered by personal interviews, field trips, questionnaire analysis, and

literature review is presented which portrays the significant value that a knowledge of various elements of production management can have for a project management team.